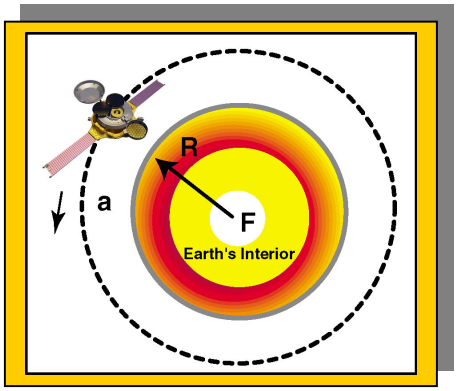
Destination L1: A Thematic Unit

Studying Orbits About Bodies in Space

TEACHER GUIDE – MATHEMATICS

BACKGROUND INFORMATION



Using a surprisingly simple relationship, Kepler's Third Law, we can study the orbit of a spacecraft about a body in space. We can study the basic parameters of (1) the time our spacecraft will take to circle the body once (called the "Period") and (2) its average distance from the body (we will call this "A"). Kepler determined this law in 1619 after having spent the previous 19 years studying the best data on the orbit of Mars. This equation is empirical, that is, based on the very careful analysis of data.

NATIONAL SCIENCE STANDARDS ADDRESSED

(Source – *National Science Education Standards)*

Grades 5-8

Science As Inquiry
- Abilities Necessary to do scientific inquiry
- Understandings about scientific inquiry

Earth and Space Science
- Earth in the Solar System

History and Nature of Science
- History of science

(View a full text of the National Science Education Standards.)

NATIONAL MATHEMATICS STANDARDS ADDRESSED

(Source – *Principles and Standards of School Mathematics)*

Grades 6-8

Numbers and Operations
- Understand numbers, ways of representing numbers, relationships among numbers and number systems.
- Understand meanings of operations and how they relate to one another.
- Compute fluently and make reasonable estimates.

Algebra
- Use mathematical models to represent and understand quantitative relationships.
- Represent and analyze mathematical situations and structures using algebraic symbols.

Geometry
- Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships.
- Use visualization, spatial reasoning, and geometric modeling to solve problems.

Problem Solving
- Solve problems that arise in mathematics and in other contexts.

Connections
- Recognize and apply mathematics in contexts outside of mathematics.

(View a full text of the Principles and Standards for School Mathematics.)

NATIONAL TECHNOLOGY STANDARDS ADDRESSED

(Source – *National Technology Education Standards)*

K-12

Technology productivity tools

Students use technology tools to enhance learning, increase productivity, and promote creativity.

Technology problem-solving and decision-making tools

Students employ technology in the development of strategies for solving problems in the real world.

6-8

Use content-specific tools, software, and simulations to support learning and research.

Select and use appropriate tools and technology resources to accomplish a variety of tasks and solve problems.

Select and use appropriate tools and technology resources to accomplish a variety of tasks and solve problems.

(View a full text of the National Technology Education Standards.)

MATERIALS

For the teacher:
- Teacher Guide Supplement, Process Frame

For each group of three to four students:
- Student Spreadsheet Kepler Excel spreadsheet

For each student:
- Student Reporting Sheet "Studying Orbits About Bodies in Space"
- Student Activity "Studying Orbits About Bodies in Space"

PROCEDURE

1. Using the background information in the Student Activity "Studying Orbits About Bodies in Space," students should fill in the Process Frame on the student reporting sheet. The Process Frame is a technique that students can use to practice retelling a procedure. This technique can help students see various ways that authors organize materials in order to inform. The first part of this Process Frame involves having students list the assumptions in the background information. Next, students define the variables and identify the equation used to figure the period of a satellite about a planet. Finally, students write out the process for solving the equation. Possible student responses for the Process Frame and questions are found on the Teacher Guide Supplement.

Alternate Strategy Tip

You may wish to have students use this formula to investigate satellites at different altitudes above several planets. Interested students may even want to research the altitude of natural and artificial satellites above other planets.

2. Once students have an understanding of how the formula works from the example provided, ask them to solve the problem in the procedure. This will allow students to compare the orbital period of a satellite 150 miles above the planet Mars with a satellite that is 150 miles above Earth. Circulate around the room and offer assistance as needed. Students should have a good understanding of the mathematics involved prior to proceeding to the technology application.

3. Instruct students to complete the procedure in the technology application section of the student activity sheet. For starters, you may want to have the students plug in the numbers given in parenthesis in order to check the work in the background section. Once students have completed this procedure, have them answer questions 1 and 2 on their reporting sheet.

4. In question 3, students can use this same spreadsheet to calculate the orbital period of a satellite with an altitude of 150 miles above each of the planets. Remind them to change the body radius, reference period, and Starting (A+B) which equals body radius plus 150 for each planet in the chart. They do not have to use the macros function to find the orbital periods. Students should then fill in the chart and answer questions 3 A-C.

5. Question 4 asks students to use the same spreadsheet to compare the orbital periods of the moons of Earth and Mars. Remind students to use the metric units for the body radius and to add the body radius to the distance to the moons in order to compare orbital periods. Students should fill in the chart and answer questions 4 a and 4 b.

6. To wrap up this session, ask students to think about satellites in orbit around the Earth. Ask questions similar to the following:
   - Why do we have satellites in orbit around the Earth? What are their purposes? (Expect answers such as weather satellites for monitoring weather conditions across the globe, communications satellites for television and computers, military satellites for security and intelligence, International Space Stations for human habitation of space, etc.)
   - Why is it important to know the orbital period of these satellites? (Students may suggest that knowing the orbital period would be important for knowing where the satellite is in order to communicate with it or maintain it.)
   - Why might it be necessary to think about the orbital periods of orbits above or below a certain point? (Students may suggest that satellite orbits may decay, or satellites may tend fall out of orbit [e.g., Mir] so it may be necessary to move a satellite to a new orbit.)

7. Students interested in learning more about the altitudes of various satellites should check out http://howstuffworks.lycos.com/satellite7.htm for a listing of some of the types of satellites located at various altitude bands.

TEACHER RESOURCES

Billmeyer, R. and Barton, M.L. 1998. Teaching Reading in the Content Areas, If Not Me, Then Who? Mid-continent Research for Education and Learning. Aurora CO.

URLs

http://howstuffworks.lycos.com/satellite9.htm
Information about how satellites work

http://liftoff.msfc.nasa.gov/academy/rocket_sci/orbmech/vel_calc.html
NASA's orbital period and velocity calculator

http://www.jpl.nasa.gov/basics/
JPL's Basics of Space Flight